Website : jurnal.umj.ac.id/index.php/icecream

Openrouteservice Pedestrian Reach Analysis on Road Networks Around Metro Stations

Lutfi Prayogi[1,2*], Ari Widyati Purwantiasning[2], Dedi Hantono[2], Yeptadian Sari[2]

[z]Department of Engineering Systems and Services, Faculty of Technology, Policy, and Management, Technische Universiteit Delft, The Netherlands
[2]Department of Architecture, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Indonesia
**Email address of corresponding author: l.prayogi@tudelft.nl*

ABSTRACT

This article examines the road networks around two metro systems, that are Jakarta MRT North-South (Bundahan HI-Lebak Bulus Grab) and Amsterdam Metrolijn 52 (Noord-Zuid). This article analyses the road network around the mentioned metro stations, finding out how the road networks support for or restrain from accessing the stations among pedestrians. This article uses Openrouteservice to analyse the pedestrian reach of the road networks around the stations. Theories on road networks that support for higher use of a transit stop are used for interpreting the findings from the Openrouteservice pedestrian reach analysis. It was found that in general the road networks around Amsterdam Metrolijn 52 stations better supports for pedestrians accessing them than the road networks around Jakarta MRT North-South stations. Stations having best pedestrian reach have surrounding road networks that are station-oriented and have smaller blocks.

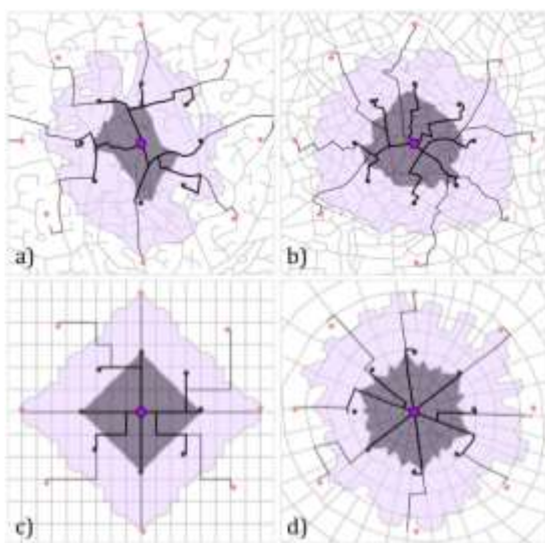
Keywords: Openrouteservice; pedestrian reach; metro stations

1. Introduction[Times New Roman 12]

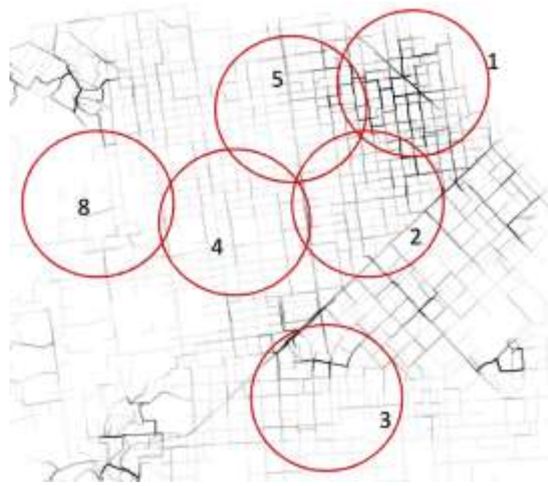
Jakarta MRT North-South (Bundaran HI-Lebak Bulus Grab) and Amsterdam Metrolijn 52 (Noord-Zuid) are two new metro systems whose dates of start of operation are close by. Jakarta MRT N-S started its operation on 24 March 2019 while Amsterdam Metrolijn 52 on 22 July 2018. MRTJ N-S spans 15.7 km, utilises 6 coaches per trainset, and operates on 5-10 minutes frequency [1]. Meanwhile, Metrolijn 52 spans 9.7 km, utilises 6 coaches per trainset, and operates on 6-7.5 minutes frequency [2]. In 2019, the average daily patronage of MRTJ N-S was 5,900, lower than the figure of Metrolijn 52 at 8,600. The figures don't seem to correspond well with the population and built environment density of the area surrounding the systems. In a glance the population and built environment density of the area surrounding MRTJ N-S is higher than the ones around Metrolijn 52. It can be argued that there are issues regarding the built environment around MRTJ N-S that account for the system's lower daily patronage than Metrolijn 52's.

The Netherlands has been well known as a country that comprehensively planned their cities' built environment and transit systems [3-5]. The comprehensive planning includes controlling of urban sprawl and revitalization of inner cities and station areas. It can be assumed that the built environment, including the road networks, around Metrolijn 52 have been optimised to support the system. This article intends to examine the road networks around MRTJ N-S and Metrolijn 52 stations. This article intends to find out the road networks that support for or restrain from accessing the stations among pedestrians. This article also intends to find the features of the road networks around Metrolijn 52 stations that are presumably unavailable in the areas around MRTJ N-S stations.

Researchers [6] summarised some works regarding the relation of road network design around a transit stop and the amount of transit passengers using the transit stop. They highlighted the works of Garcia-Palomares, et al. [7] and Ramezani, et al. [8] that collected the transit passenger data of some transit systems in some cities and analysed the role of the road network design around the transit stations in generating the patronage of the transit stations. Garcia-Palomares, et al. [7] concluded that there are at least three street network patterns that generate different potential patronage for a transit stop, that are irregular, orthogonal, and station-oriented. They concluded that the station-oriented street network pattern generates highest potential patronage for a transit stop, followed by the orthogonal and irregular street network patterns. Figure 1 shows the three street network patterns analysed and concluded by Garcia-Palomares, et al. [7]. Meanwhile, Ramezani, et al. [8] concluded that a road network with higher penetrability (i.e., having smaller block size) generates higher patronage for a transit stop. Figure 2 shows the areas having different block sizes analysed by Ramezani, et al. [8]. Their conclusion is in line with Yavuz and Kuloglu's [9] argument in Fajar and Purwantiasning [10], that a road network smaller block sizes provide for better internal sirculation. Researchers [6] concluded from their works that different road network patterns and block sizes induced different perceived distance among the passengers, thus induced different potential for them in accessing the transit stop.



Source: (Garcia-Palomares, et al., 2018)
Figure 1: Three street network patterns that generate different potential patronage for a transit stop: a) irregular (low-density), b) irregular (high-density), c) orthogonal, and d) station oriented



Source: (Ramezani, et al., 2017)
Figure 2: Examples of street networks with varied penetrability and varied block sizes

Openrouteservice is a GIS-based spatial analysis tool developed by Heidelberg Institute for Geoinformation Technology (HeiGIT), University of Heidelberg, Denmark [11]. It uses enhanced city maps as its base map, as its object for analysis. Besides having points, lines, and areas, the maps also have additional attributes such as elevation, line travel allowance and restriction, travel boundary, land cover, land use, population, etc. Openrouteservice Maps (OSM) aggregates data from various map sources, such as OpenStreetMap, OpenCycleMap, OpenTopoMap, etc., making it feature-rich and stay updated. In regards of pedestrian infrastructure, OSM includes pedestrian-specific infrastructures, such as pedestrian bridges, park footpaths, etc. Besides, OSM also includes cycle-specific infrastructures, such as cyclepaths.

Openrouteservice provides various spatial analysis features, one of which is pedestrian reach analysis. Openrouteservice analyses routes that can be travelled by a pedestrian from a point in the OSM. It can analyse the points a pedestrian can reach by walking from a point within a specified time or distance. Furthermore, Openrouteservice can produce an isochrone of the area a pedestrian can reach by walking within a specified time or distance and calculates the area size of it. In Jun's, et al. [12] work, the pedestrian reach isochrone is termed pedestrian catchment area (PCA). Besides, Openrouteservice also provides reach analysis for motorists, cyclists, transit passengers, and wheelchair users. In regards of the reach analysis, Openrouteservice excels against similar analysis in ArcGIS and QGIS by having an always updated base map (i.e., the Openrouteservice aggregated map) that is unavailable in basic ArcGIS and QGIS [13]. Figure 3 shows an example of an isochrone of pedestrian reach from Bundaran HI MRTJ station.

Source: (Openrouteservice, 2021)
Figure 3: An isochrone of pedestrian 14-minute reach, with 5-minute interval, from Bundaran HI MRTJ station

2. Material and Methods

This research intended to answer two questions, that are "In regards of the potential to supporting the patronage of the stations, how do the road networks around MRTJ N-S stations compare to the ones around Metrolijn 52?" and "What are the features of the road networks around Metrolijn 52 that support the patronage of the stations?" The research questions were tried to be answered using descriptive-qualitative approach. To answer the first question, Openrouteservice pedestrian reach analyses were carried out on 13 MRTJ N-S and 8 Metrolijn 52 stations, looking for the shape and size of the isochrones (i.e., the pedestrian reach coverage area).

Following Jun's, et al. [12] and Sung'es, et al. [14] conclusion on the maximum walkable distance to and from transit stops, the parameter used for the reach analysis was 10-minute (800 m) walking. The isochrone shape is then compared to the theoretical optimum shape. Assuming that the station is situated in a middle of a plain where one can roam freely in any direction from the station, the optimum shape will be a full circle. The isochrone shape close to the theoretical optimum shape will look like figure 1(d) [7]. The isochrone size is also compared to the theoretical maximum area. The theoretical maximum area size will be the size of a circle with 800 m (10-minute walking) radius. Thus, the theoretical maximum area will be 2.01 km2. To answer the second question, the isochrones of selected stations were analysed within the framework of the theories regarding road network design supporting for higher patronage of a transit stop. The road network pattern and orientation and the block sizes within the isochrones were investigated.

3. Results and Discussions

3.1. Overview of the pedestrian reach isochrone of stations

In general, pedestrian reach isochrones of Metrolijn 52 stations look more like full circles than the ones of MRTJ N-S. One significantly distorted isochrone is #3 Amsterdam Centraal's, in which next to the north of it is a canal. Out of 13 MRTJ N-S stations, three stations (#7 ASEAN, #8 Blok M BCA, and #9 Blok A) have isochrones that look like circles. Three stations (#6 Senayan, #11 Cipete Raya, and #13 Lebak Bulus Grab) have isochrones that look more like rectangles. Figure 4 shows the pedestrian reach isochrones of MRTJ N-S and Metrolijn 52 stations in an almost identical scale.

Source: (Openrouteservice, edited by author, 2021)
Figure 4: Pedestrian 10-minute reach of Jakarta MRT North-South stations (left) and Amsterdam Metrolijn 52 (right)

In general, pedestrian reach coverage area of Metrolijn 52 stations are larger than the ones of MRTJ N-S. The average pedestrian reach coverage area size of Metrolijn 52 is 1.44 km2, 0.19 km2 larger than the area size of MRTJ N-S'. In other word, it is 190,000 m2 larger. The largest area from all the analysed stations is the one of Metrolijn 52's De Pijp station at 1.58 km2 or 79% of the theoretical maximum area. The smallest area is the one of MRTJ N-S' Dukuh Atas BNI station at 0.98 km2 or 49% of the theoretical maximum area. It is worth to mention that the smallest pedestrian coverage area among Metrolijn 52 stations, that is the one of Noord station at 1.32 km2 or 66% of the theoretical maximum area, is still larger than the average of MRTJ N-S'. Table 1 shows the complete pedestrian reach coverage area of the analysed stations.

Table 1: Metro stations' pedestrian reach coverage area calculated using Openrouteservice

Metro stations' pedestrian reach coverage area

Maximum area: 2,01 km2

#	Jakarta MRT North-South	Area (in km2)	% of max area
1	Bundaran HI	1,32	66%
2	Dukuh Atas BNI *(lowest)*	0,98	49%
3	Setiabudi Astra	1,29	64%
4	Bendungan Hilir	1,15	57%
5	Istora Mandiri	1,26	63%
6	Senayan	1,00	50%
7	ASEAN	1,44	72%
8	Blok M BCA	1,41	70%
9	Blok A *(highest)*	1,54	77%
10	Haji Nawi	1,32	66%
11	Cipete Raya	1,11	55%
12	Fatmawati	1,21	60%
13	Lebak Bulus Grab	1,16	58%
	Average	**1,25**	**62%**

#	Amsterdam Metrolijn 52	Area (in km2)	% of max area
1	Noord *(lowest)*	1,32	66%
2	Noorderpark	1,39	69%
3	Amsterdam Centraal	1,45	72%
4	Rokin	1,43	71%
5	Vijzelgracht	1,39	69%
6	De Pijp *(highest)*	1,58	79%
7	Europaplein	1,55	77%
8	Amsterdam Zuid	1,43	71%
	Average	**1,44**	**72%**

Source: (Author, 2021)

3.2. Road network pattern and orientation

Metrolijn 52's Europaplein station, the station with the second largest pedestrian reach coverage area, can be said as having a station-oriented road network around it. There are four main roads leading to it, that are Scheldestraat from the north, Rooseveltlaan from the northeast, President Kennedylaan from the east, and Europaboulevard from the south. The station is situated at the intersection of the four roads. ASEAN station, the station with the second largest pedestrian reach coverage area among MRTJ N-S stations, also can be said as having a station-oriented road network around it. It is situated at the intersection of two main roads, that are Jl. Sisingamangaraja-Jl. Panglima Polim spanning north-south and Jl. Trunojoyo-Jl. Kyai Maja spanning east-west. It can also be said, aside from being station-oriented, the road networks around the two stations are also perpendicular. Smaller roads branch out perpendicularly from the main roads leading to the stations. Figure 5 shows the road network around Europaplein station while figure 6 shows the road network around ASEAN station.

Source: (Openrouteservice, edited by author, 2021)
Figure 5: The road network within Europaplein station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

Source: (Openrouteservice, edited by author, 2021)
Figure 6: The road network within ASEAN station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

Meanwhile, Senayan station, the station with the second lowest pedestrian reach coverage area, has a surrounding road network that is rather far from being a station-oriented road network. It is not situated at an intersection. It is situated at a stretch of road with few through roads branching from it. The through roads branching from the stretch of road are Jl. Pintu Satu Senayan, Jl. Tulodong Atas 2-Kawasan SCBD, and Jl. Senopati that are no less than 200 m from the station point. The streets branching from the stretch of road within 200 m from the station point are internal driveways of the aligning land parcels. The road network around the station is not perpendicular either. Figure 7 shows the road network around Senayan station.

Source: (Openrouteservice, edited by author, 2021)
Figure 7: The road network within Senayan station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

3.3. Block size

Metrolijn 52's De Pijp station, the station with the largest pedestrian reach coverage area, can be said as having a finely penetrable road network around it. The block sizes around it are relatively small, with the biggest one is the one circling Sarphatipark east of the station at 135 m x 316 m. It needs to be remembered that the park is also penetrable by pedestrians. Blok A station, the station with the largest pedestrian coverage area among MRTJ N-S stations, also can be said as having a finely penetrable road network around it. The block sizes at the southern part of the area are relatively very small, with the smallest one is the one east of SDN 1 Gandaria Utara at 30 m x 30 m. Figure 8 shows the road network around De Pijp station while figure 9 shows the road network around Blok A station.

Source: (Openrouteservice, edited by author, 2021)
Figure 8: The road network within De Pijp station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

Source: (Openrouteservice, edited by author, 2021)
Figure 9: The road network within Blok A station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

Meanwhile, Dukuh Atas BNI station, the station with the lowest pedestrian reach coverage area, can be said as having a less penetrable road network around it. There are at least five impenetrable large land parcels around it. To the north of the station there are UOB Plaza-Thamrin Nine, Menara BCA-Hotel Indonesia Kempinski-Grand Indonesia, and Mandarin Oriental Hotel-German Embassy land parcels and to the south of the station there are Wisma BNI 46 and The Landmark Center land parcels. The blocks right next west of the station are also relatively large at around 60 m x 285 m. The blocks along Jl. Sumenep, northeast of the station, are also relatively large, with the largest one bordered by Jl. Sumenep and Jl. Dokter Kusuma Atmaja measures at 80 m x 530 m. Figure 10 shows the road network around Dukuh Atas BNI station.

Source: (Openrouteservice, edited by author, 2021)
Figure 10: The road network within Dukuh Atas BNI station 10-minute walking pedestrian reach isochrone: OSM-original (left) and highlighted (right)

4. Conclusion

We may conclude from the previous section that the road networks surrounding Metrolijn 52 stations support for higher patronage of the stations than the ones of MRTJ N-S stations. In general, the road networks provide for larger pedestrian reach coverage, potentially bringing more pedestrians to the stations for using the metro system. The road networks provide for larger pedestrian reach coverage by being station-oriented and having small block sizes. The road networks that are station-oriented, have small block sizes, and thus provide for larger pedestrian reach coverage, are also available surrounding some limited MRTJ N-S stations. Some MRTJ N-S stations score low in their pedestrian reach coverage. The road networks around them are not station-oriented and have large land parcels and block sizes.

It is worthy to juxtapose the outputs of the Openrouteservice analysis presented in this article with the outputs of similar spatial analysis, such as space syntax analysis showing the integration and connectivity of the road networks around the stations. Such juxtaposition can provide for a more comprehensive explanation on how a road network may support for or restrain from accessing a station among pedestrians. It can also better show the features of a road network that support for or restrain from accessing a station among pedestrians.

Acknowledgement

This research was fully funded by Hibah Program Kompetisi Kampus Merdeka (01/E1/PPK/KM.05.03/2021).

References

[1] PT Mass Rapid Transit Jakarta (PT MRTJ). (Retrieved in July 2021) https://jakartamrt.co.id/id

[2] Gementee Vervoerbedrijf (GVB). (Retrieved in July 2021) https://over.gvb.nl

[3] Goedman J, Houtsma WK, Zonnevel W. Dutch spatial planning: From implicit towards explicit sustainable urban development. *Proceeding of 44th ISOCARP Congress*; 2008.

[4] Ministry of Infrastructure and the Environment. (2012). *35 icons of Dutch spatial planning*.

[5] Ministry of the Interior and Kingdom Relations. *Draft of the national strategy on spatial planning and the environment*; 2019.

[6] Prayogi L & Hantono D. Bus Rapid Transit-oriented Development: A Review of Built Envrironment Qualities Potentially Triggering Bus Rapid Transit Passengers' Modal Shift. *IJERT* 2018, 7(8):302-305.

[7] Garcia-Palomares JC, Sousa Ribeiro J, Gutierrez J, Sa Marques T. Analysing proximity to public transport: The role of street network. *Boletín de la Asociación de Geógrafos Españoles* 2018; 76:102-130.

[8] Ramezani S, Pizzo B, Deaking E. Determinants of sustainable mode choice in different socio-cultural contexts: a comparison of Rome and San Fransisco. *Int J of Sust Trans* 2017.

[9] Yavuz A & Kuloğlu N. Permeability as an Indicator of Environmental Quality: Physical, Function, Perceptual Components of The Environment. *World J of Env Res* 2014; 4(2):29–40.

[10] Fajar P & Purwantiasning AW. Kajian konsep imageability dan permeability dalam pengembangan kawasan pusat kota Kowloon, Hong Kong. *BORDER J Ars* 2020; 2(2):65-81.

[11] Heidelberg Institute for Geoinformation Technology (HeiGIT). (Retrieved in October 2021) https://openrouteservice.org

[12] Jun MJ, Choi KC, Jeong JE, Kwon KH, Kim HJ. Land use characteristics of subway catchment areas and their influence on subway ridership in Seoul. *J of Trans Geo* 2015; 48:30-40.

[13] Prayogi L, Sari Y, Prima TS. Perspectives in Evaluating Pedestrian Facility within Transit-oriented Development Context. *IOP Conf Series: Earth and Env Sci* 2021; 878.

[14] Sung H, Choi K, Lee S, Cheon SH. Exploring the impacts of land use by service coverage and station-level accessibility on rail transit ridership. *J of Trans Geo* 2014; 36:134-140.